6 Research Needs

6.1 Health-Related Research

The relationship of occupational crystalline silica exposure with silicosis and other silica-related diseases is well documented in the literature. However, the mechanisms and particle characteristics that cause silicosis and other silica-related diseases have not been precisely defined. Prevention of silicosis, lung cancer, and other silica-related diseases can be facilitated by the following:

- Development of methods for earlier detection or more definitive noninvasive evaluation of silica-related pulmonary disease, such as methods to improve the sensitivity of radiography for detecting silicosis (these methods were reviewed by Wilt et al. [1998] and Talini et al. [1995])

- Further in vitro and in vivo studies of mechanisms for development of

  — silicotic nodules [Craighead 1996]

  — autoimmune diseases

  — DNA damage by silica particles [Saffiotti et al. 1994]

- Further in vitro and in vivo studies of the toxicity and pathogenicity of

  — alpha quartz compared with its polymorphs [Craighead 1996]

  — crystalline silica compared with crystalline glass, amorphous silicone, and silicates [Craighead 1996]

  — crystalline silica compared with substitute materials for abrasive blasting and other tasks that use crystalline silica

  — dust mixtures that contain crystalline silica [Craighead 1996; Donaldson and Borm 1998; Dufresne et al. 1998]

  — quartz contaminated with trace elements [Castranova et al. 1997]

- The association of surface properties of silica particles with specific work processes and health effects

- Cellular, molecular, and animal models of silica carcinogenesis to explore whether silica dust is an initiator or a promoter of lung cancer [Craighead 1996] and to evaluate a dose-response relationship

- Animal models of individual susceptibility and the development of fibrosis [Craighead 1996], including the translocation of silica particles from the lungs [Adamson and Prieditis 1998]

- Animal models of the adverse effects of crystalline silica on the kidneys and liver

- Routes and kinetics of lymphatic transport and deposition of silica particles [Craighead 1996]

Further epidemiologic studies and surveillance of silica-exposed workers are needed to do the following:

- Determine the exposure-response relationship between occupational silica dust exposure and lung cancer in nonsmokers
- Determine why lung cancer risks appear to be higher in silicotic workers (e.g., determine the histologic type and anatomic location of lung cancers in workers with and without silicosis [Ducatman et al. 1997])
- Evaluate exposure-response relationships between occupational silica dust exposure and (1) TB [ATS 1997] and (2) changes in cellular components (lymphocytes, Clara cell protein) or immunoglobulin concentrations
- Determine the relationship between occupational exposure to silica dust and
  - —TB in silica-exposed workers without diagnosed silicosis
  - —clinically significant changes in the lung function of nonsmokers
  - —emphysema in nonsmokers
  - —gastric cancer and other nonpulmonary cancers
- Gather uniform national and international prevalence and incidence data about silicosis cases to identify industries, occupations, and work areas where preventive measures could be implemented [CSTE 1996; Wagner 1997]
- Gather prevalence, incidence, and mortality data about silica-related diseases such as cancer, scleroderma and other autoimmune diseases, nonmalignant renal disease, and other adverse health effects to assess morbidity and mortality risk factors and to identify areas where preventive measures could be implemented
- Determine whether silicosis or silica-related lung cancers are related to a specific gene, gene pattern, or other individual susceptibility factors
- Improve the methods for estimating historical exposures for retrospective cohort studies
- Improve the assessment of potential confounding and synergistic effects of smoking in silica-exposed workers [Checkoway 1995]
- Improve the assessment of potential confounding and synergistic effects of other carcinogens present in the work environment of silica-exposed workers [Dufresne et al. 1998]
- Determine whether adverse health effects are associated with occupational exposure to materials that could be substitutes for crystalline silica [NIOSH 1992a]

6.2 Research Related to Exposure Measurement

Reducing the OSHA and MSHA PELs for crystalline silica to concentrations below the NIOSH REL (0.05 mg/m^3 for up to a 10-hr workday during a 40-hr workweek) would require new methods that can accurately measure low airborne concentrations at the NIOSH accuracy criterion. (Limitations of

current NIOSH methods for measuring worker exposure to airborne crystalline silica are discussed in Chapter 2). Such new methods will depend on the following types of research and development:

- Reevaluation of the 10-mm nylon cyclone, the GK2.69 cyclone, or other proposed devices at exposure concentrations below 0.05 mg/m^3
- Ascertainment of the sampling efficiency of proposed samplers versus particle aerodynamic diameter
- Side-by-side comparison of proposed samplers under field conditions
- Development of samplers that can operate at higher flow rates than those currently available
- Development of working standards that use different types of filter media (e.g., PVC) to reduce errors in calibration
- Further improvement of the system used to produce replicate crystalline silica samples for the PAT Program* to
  - improve the reproducibility of interlaboratory results for silica analysis,
  - eliminate problems with sample overloading, and
  - determine how to account for bias between results from different analytical methods
- Further research to validate the feasibility of "on-filter" analysis under field conditions (preliminary investigation of particle transition between the cyclone and the sample collection cassette indicates that it is possible to improve the uniformity of particles deposited on the filter to permit an accurate on-filter analysis)
- Collaborative testing of any improved or new sampling and analytical methods to demonstrate equivalence

*This system has undergone improvements from its original form to reduce the intersample variability. Currently, intersample CV is on the order of 0.08 to 0.12. Only cursory testing of these improvements has been carried out, and further improvements may be necessary.

6.3 Research Related to the Control of Exposure

Protecting workers from crystalline silica exposures can be accomplished through a number of means. Respiratory protection and administrative controls are important means of protecting workers, but they should not be used as the primary method of preventing worker exposure. Other exposure control methods (including process modifications to eliminate hazards, substitution, and engineering controls) should be the primary focus of any safety and health program in preventing occupational exposures. For some industries, research is needed to develop cost-effective controls; whereas in other industries, work is needed to increase the availability and use of control measures and to explore barriers that prevent the introduction of control technology. Specific types of research are needed in the following industries:

- *Construction*. The construction industry presents a major challenge for protecting workers. In this industry, crystalline silica is present in many of the building materials and construction substrates (i.e., rock and soil). Silica sand is a major component of concrete and mortar and is used in the production of brick

and concrete masonry units. In addition to the ubiquitous presence of silica in construction, this industry also faces a challenge from the ever-changing nature of the worksite. These changes create two problems in the control of silica exposures. First, permanent control measures are not feasible for many worksites because of the short duration of the task (e.g., concrete cutting or coring operations). Second, the manner in which the work is performed at a worksite can create a silica exposure for workers at adjacent worksites. Control methods such as wet cutting of bricks and concrete masonry units and use of high-velocity/low-volume (HVLV) ventilation systems during cutting and grinding of concrete have been effective in reducing exposures to silica at some worksites. However, the following research is needed to improve these techniques and the feasibility of their use:

- The use of water is not a feasible control method for reducing exposures on many interior jobs or in cold temperatures. Research is needed to find methods for increasing (1) the applicability of water to more operations and (2) the use of water in applications where it is considered feasible.

- The use of HVLV ventilation involves problems such as insufficient hood capture velocity, obstruction of the work area by the control, and poor dust collector performance. Research is needed to improve the performance of HVLV systems and the feasibility of their use in other operations.

- Alternative materials and work methods can be used to reduce crystalline silica exposures. For example, concrete forms can be used to impart smoother surface finishes and reduce the need for additional grinding or rework. Additional research is needed to investigate alternative methods for blowing and sweeping on construction sites (e.g., the use of vacuums instead of compressed-air lances to remove debris from cracks in road construction).

- *Foundries*. Foundries use large volumes of sand in the molds and the cores to produce castings. In general, foundries that cast higher-temperature metals (steel, gray iron, and stainless steel) have the potential for creating higher silica exposures than foundries that cast lower-temperature metals (aluminum, brass, and bronze). The molding sand used in most foundries contains a small percentage of water and other binders. High temperatures dry the sand, making it more likely to become airborne. Various types of controls are being used in foundries, but additional research is needed:

  - Alternative processes such as the lost foam casting process have been used for some metal castings, but they require additional investigation to determine whether they can effectively reduce exposures by minimizing the amount of casting cleaning and sand handling required to produce high-quality castings.

  - Industrial ventilation is widely used to capture and contain silica-containing aerosols. However, its effectiveness is only as good as its design, installation, and maintenance. Research is needed on methods for effectively communicating the need for routine

and proper maintenance of ventilation systems.

— Automated processes in foundries need to be explored so that workers can be removed from operations that generate high silica exposures.

— The use of HVLV ventilation systems during casting cleaning needs to be evaluated.

— Alternative methods should be investigated for blowing and sweeping in foundries. Vacuums may be feasible as an alternative to compressed-air lances and dry sweeping.

- *Abrasive blasting operations*. Abrasive blasting operations have been documented to generate some of the highest crystalline silica exposures. Other blasting materials such as steel shot, steel grit, and boiler slag have been used as substitutes for silica sand. However, additional research is needed to determine the safety of substitute blasting materials. In addition, replacing silica sand with a substitute blasting material will not eliminate silica exposures when blasting on silica substrates such as concrete or granite. Many of these operations may be modifiable to reduce the amount of blasting required. Additional research is needed on alternative blasting methods such as high-pressure water jetting, slurry blasting, and vacuum blasting. All of these may reduce exposures associated with silica-containing substrates.

- *Surface and other mining*. Technology exists in the surface mining industry to control exposure to crystalline silica. However, silicosis persists because controls are often not implemented or properly maintained [NIOSH 1996b]. Effective methods are needed for informing drillers and drill owners about the need for continued maintenance and proper use of dust controls on drills. Mine workers at other than surface sites have silica exposures that have not been well characterized. For example, little or no information is available about dust control measures for hard-rock tunneling operations. Research is needed to determine which control measures provide the best protection and are feasible to implement.

- *Paints, coatings, glass, cosmetics, plastics, and cleaning products*. Crystalline silica is used in a diverse number of products, including paints, coatings, glass, cosmetics, plastics, and cleaning products. However, the hazards associated with silica exposure are often not recognized in these industries. Research is needed to develop methods for communicating hazards and controls to workers and employers. The need is for innovative technologies that can be transferred across industries. Additional research is needed to investigate the feasibility of using HVLV ventilation systems and water to reduce exposures in these industries.